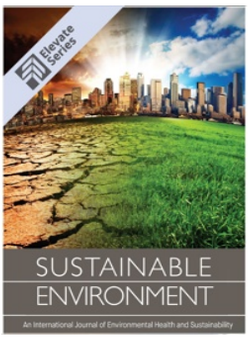

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Harnessing traditional principles and guidelines for utilization compliance and sustainability of *Maasai Alalili* systems in northern Tanzania

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ABSTRACT

Resilience in Indigenous communities and their lands faces challenges from multiple fronts, including climate change, biodiversity loss, altered biogeochemical flows, and socio-cultural transitions. Innovative solutions like Indigenous local knowledge featuring the community repositories that could enable policy practice are needed to explore, shift, and articulate such trajectories towards sustainable and desired futures. The study used a mixed-method approach to gather information on the extent to which *Maasai* communities practice traditional principles and guidelines for sustainable management of the *Alalili* systems. Purposive and stratified random sampling techniques facilitated data collection from literature review, direct field observation, key informant interviews, focused group discussions, and household surveys, which were analyzed using Chi-square and t-tests, narrative, and descriptive techniques. The findings indicate a variation between the traditional principles and guidelines reported from the surveyed literature and those recorded from the field survey. We found that the literature sparingly reported six aspects of the traditional principles and guidelines, whereas the field survey from the community comprehensively reported four harmonized aspects. More than 50% of the surveyed *Alalili* systems are currently not complying with documented management principles and guidelines from the literature and community traditions, thus increasing their proximity to the effects of degradation. We reveal that the probability of compliance is higher in the private *Alalili* category. We recommend their official recognition by policymakers and putting them into practice as a conservation initiative for supporting future rangeland sustainability and the pastoral communities' livelihood development.

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Alalili; Indigenous conservation; Rangeland management; Traditional principles and guidelines; Land-use and Land cover change

Introduction

The global change in climate, land use, and land cover associated with an increasing anthropocentric demand on overutilizing natural resources to sustain livelihood, are reported as key challenges facing pastoralists who occupy more than 75% of the global land surface (Eldridge & Beecham, 2017; Johnsen et al., 2019; Schils et al., 2022). Such factors, including the mismanagement and transformation of rangelands and the related silvo-pastoral systems into unproductive forms, have contributed to the loss of suitable pastures from which different indigenous pastoral communities depend (Babune & Mshuda, 2020; Wiethase et al., 2023; Naah & Braun, 2019). The Global Landscapes Forum, in collaboration with the United Nations Environment Programme (UNEP), pushed the United Nations (UN) initiatives to restore the degrading rangelands as a way of acknowledging the declaration of the UN Decade for Ecosystem Restoration, 2021–2030 (UNEP & FAO, 2020). Currently, incorporating diversities of indigenous and/or locally based traditional rangeland management and environmental conservation technologies in decision-making tools is one of the significant initiatives with high priority toward restoring degraded rangelands (Bruchac, 2014; FAO, 2015; Hezron et al., 2025; UN, 2009; Wangchuk et al., 2023). This is strongly supported by the UN 2030 Agenda for Sustainable Development, which calls for an understanding, valuation, and integration of indigenous people and the local knowledge rich in suitable traditional principles and guidelines that best suit for management and protection of rangelands from unsustainable use (Dawson et al., 2021; UN, 2015).

Alalili systems indigenous to *Maasai* communities in East Africa, as defined by Hezron et al. (2024, 2025), are among many local and traditional knowledges in the world today (Wangchuk et al., 2023) through which pastures are reserved for subsequent grazing during dry seasons (Mpondo et al., 2021; Sangeda & Maleko, 2018;

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Selemani, 2020). Like other indigenous communities and their traditional technologies in various regions (UNEP, 2023), *Maasai* and their *Alalili* practices have been useful in maintaining nature and managing the suitability of pastures across East African rangelands for their livestock and wild ruminants (Goldman & Riosmena, 2013; Nelson, 2012; Saruni, 2019). For centuries, it has been evident that locally based, cultural practices and traditional management institutions of *Maasai* communities have been informally contributing to the design, promotion, and implementation of principles and guidelines for assessing qualities and ecosystem health through sustainable environmental management (Goldman, 2011; Kilongozi et al., 2005; Olekao, 2017; Saruni, 2018). However, the *Alalili* systems and their associated biodiversity are undergoing decline and degradation partly because of socio-cultural transformation, changes in climate, unsustainable land use practices, and political regimes (Hezron et al., 2024, 2025).

Moreover, the traditional regulations and devised local rules by *Maasai* pastoralists have been used in setting, assessing, and managing the key criteria for utilization compliance of pastures for sustainable rangeland and biodiversity conservation (Mapinduzi et al., 2003; Nyariki et al., 2005; Selemani, 2020). The existence of these traditional principles and guidelines for sustainable management and utilization compliance of *Alalili* systems is separately and sparingly reported in the literature, with little comprehension, consistency, and scarcely consolidated. Their little recognition might be the cause of the reduced quality of pastoral communities' livelihood, increasing degradation threat of *Alalili*, and pasture scarcity (Liniger & Mekdaschi Studer, 2019; Saruni, 2018; URT, 2014). The existing information is limited to defining the type of grazing stocks as reported by Mpondo et al. (2021), Olekao (2017), Saruni (2019), and Goldman (2011), but not harmonized with the information reported by Selemani (2020) and Sangeda and Maleko (2018). More information describes the traditional principles that guide time for grazing in the *Alalili* systems as partially reported by Mpondo et al. (2021), Selemani (2020), and Goldman (2011). Although a detailed grazing time that was described by Saruni (2019) is not harmonized with the time reported by Olekao (2017) and Sangeda and Maleko (2018), which shows varied information on the opening and closing time of the *Alalili* systems. The management practices that guide who should make decisions about utilizing the *Alalili* systems and conducting security patrols, as reported by Saruni (2019), Sangeda and Maleko (2018), and Goldman (2011), partially correspond with similar principles reported by Olekao (2017) and Nelson (2012). On the other hand, Selemani (2020) and Sangeda and Maleko (2018) partially reported that there are changes in the ways of defining and clarifying the use and protection of *Alalili* systems. Additionally, while these guidelines have been practiced by *Maasai* communities in pasture and rangeland foraging practices, the extent to which communities have complied with the guidelines remains unreported (Mwilawa et al., 2008).

Therefore, this study aimed to characterize the traditional and indigenous principles and guidelines used to guide compliance in the process of utilizing and locally managing the *Maasai Alalili* systems. It prepared a harmonized checklist of the reported traditional principles from the literature while incorporating the non-reported ones for improved suitability and correspondence. Additionally, this work evaluated the applicability of the documented principles towards better management of *Alalili* systems in conjunction with the principles reported in other literature. It surveyed the community's perception of compliance with the utilization of *Alalili* systems concerning predetermined management principles and implementation practices among the *Maasai* communities across the rangelands of northern Tanzania. A comprehensive checklist and formal reporting of traditional or indigenous management principles and guidelines will contribute to achieving the Sustainable Development Goals, as stipulated in the declaration of the UN Decade on Ecosystem Restoration and CBD (NCA, 2022; Secretariat of the United Nations Convention on Biological Diversity, 2021).

Materials and methods

Study area

This work was undertaken in the *Maasai* pastoral communities inhabiting areas rich in rangelands and the associated *Alalili* systems of northern Tanzania. The area is located between 2°12'04" and 5°56'29" South and 36°11'43'"and 36°51'30" East (Figure 1) and lies at an elevation range of 659–2,123 m above sea level (Hezron et al., 2024). It has an average annual temperature of 30 ° C (maximum) and 18° C (minimum) while receiving an average annual precipitation of 650 mm (Mbinile et al., 2020; Olarinoye et al., 2020). The area is characterized by a bimodal rainfall season: long rains fall between March and May, while short rains fall between October and December (Manning, 2020; Mbinile et al., 2020; Mwalyosi, 1992; URT, 2018). The nature of landforms and soils featuring the area is volcanic at large, whose vegetation comprises grasslands, woodlands (bushlands), and some montane forest patches (Mapinduzi et al., 2003). It comprises useful *Maasai* social-cultural and traditional practices for conserving natural resources, such as those located in

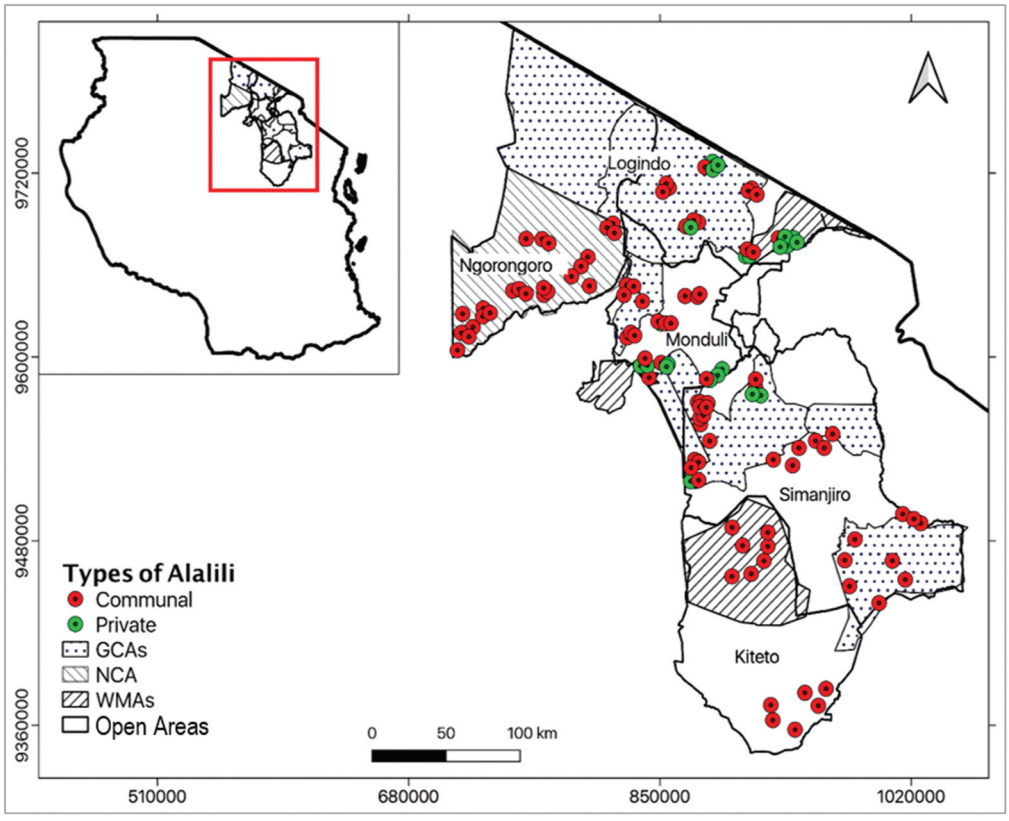


Figure 1. A map showing the surveyed *Maasai Alalili* systems across different land use categories in rangelands of northern Tanzania.

geological sites of the Ngorongoro Conservation Area, making it one of UNESCO's global heritage and biosphere reserves (NCA, 2022; URT, 1979). Pastoralism is the major economic activity through which the indigenous *Maasai* community generates its family wealth for sustained livelihood, whereby traditional grazing systems are land use practices useful for both livestock and wildlife (Homewood et al., 2009; NTRI, 2019).

Research design and sampling techniques

A cross-sectional research design was applied, adopting mixed purposive and stratified random sampling techniques (Elfil & Negida, 2017; Portier et al., 2000). The study site covered two regions and five districts whose administrative boundaries were marked purposively through Quantum Geographical Information System (Q-GIS) software to enhance the sampling process (Hezron et al., 2024; Msalilwa et al., 2020). The sample districts were Longido, Ngorongoro, and Monduli for the Arusha region and Simanjiro and Kiteto for the Manyara region. The rangelands in *Maasai* land were classified into four strata concerning existing land use types in Arusha and Manyara regions, where *Alalili* practices are allowed as stipulated in the Tanzanian natural resources management policies (URT, 1999a; Leader-Williams et al., 1996; The Local Government (Urban Authorities) Act, 1982). Land use strata were Game-controlled Areas (GCA), Ngorongoro Conservation Area (NCA), Wildlife Management Areas (WMA), and unprotected open grazing areas (OA) vested to village lands plotted through Q-GIS while distinguished by using the topographic map of the sampled region and shape files (Hezron et al., 2024; Msalilwa et al., 2020; URT, 1999a, 1999b). The size of each *Alalili* system was documented for an enhanced estimation of the stocking rate. Key informant interviews were used to identify a total of 298 *Alalili* systems, whereby 40% (119 *Alalili* systems) were sampled through random number tables designed for each sample district (Hezron et al., 2024). The land use category within which sample *Alalili* systems were located was verified by using the ground-truthing technique (Zhou, 1996). The study adopted a purposive sampling technique to enhance key informant interviews and focus group discussions in each sample district (Elfil & Negida, 2017; Showkat & Parveen, 2017). The key informants who were sampled for the study were the district game officers (DGOs), rangeland management officers (ROs), ward/village executive officers (VEO/WEO), and members of the village rangeland management committee (Hezron et al., 2024). A random sampling of

Table 1. Sample size for household survey in each district across the study area

District	Longido	Monduli	Ngorongoro	Simanjiro	Kiteto	Total
N	26	29	26	40	35	156
n	24	27	24	36	32	143

individual respondents was done for the household survey, whereby sample respondents were obtained according to Slovin's formula as shown in model Equation 1 (Rono, 2018).

$$n = \frac{N}{1 + N.(e^2)} \quad (1)$$

Whereby, n is the sample size, N stands for the total number of target households who dwell around sampled *Alalili* systems and responded to the survey in each district, and e^2 stands for the squared level of precision (i.e. squared 5% or 0.05). The calculated sample sizes for each district are presented in Table 1.

Attributes used for assessing the community's compliance with the utilization of Alalili systems

Six compliance attributes were documented and coded for an enhanced socio-economic survey while assessing the surrounding pastoral community's compliance with traditional principles and guidelines for managing *Alalili* systems. These were: grazing season identification, the modality of conducting grazing activities, availability of managing institutions, the existence of institutional arrangements, abiding by formalized laws and by-laws, and observing the existing traditional rules and regulations (Table 2).

Table 2. Summary of the attributes for utilization compliance (source: Field survey, 2022)

Code No.	Compliance attribute	Description of the attribute
C1	Grazing seasons identification	Weather changes, cropping season, or both weather changes and cropping season
C2	Grazing modalities	(1) All types of livestock graze in open grazing areas during the wet season with regard to the plentiful availability of forage resources. (1) At the beginning of the dry season, all types of livestock graze in *Alalili* which is far from residential areas except calves, weak/sick, and lactating livestock. (1) Only calves, weak/sick livestock, lactating ones, goats, and sheep are allowed to graze in the *Alalili* located closer to residential areas at the beginning of the acute dry season. (1) No definite number of livestock is allocated for grazing in the *Alalili*. Currently, the livestock herd size grazed in the *Alalili* systems depends on its area coverage and the number of livestock owned by the households around it. (1) Healthy livestock at maturity age should be grazed in *Alalili* once a day (Morning or evening) before being swept to the *Ronjo* (short-term livestock camps) or water points. (1) Calves and weak livestock are grazed in *Alalili* twice a day. (1) Four to five hours a day may be used for grazing livestock in *Alalili*.
C3	Management Institutions	Village rangeland committee, *Laigwanani*, *Morani* (*Landiis*, *Korianga*, and *Nyangulo*), and *Laiboni*
C4	Institutional arrangements	(1) Plan the grazing seasons in a village. (1) Set the standard and status that determines the time to open *Alalili* for livestock to graze. (1) Formulating laws, by-laws, rules, and management regulations at the village level. (1) Set the punishment for anybody who violates the laws or by-laws. (1) Establish the boundaries to differentiate areas for *Alalili* and open pasture lands.
C5	Laws and By-laws	(1) Nobody shall be allowed to graze livestock in *Alalili* before the opening season (critical dry season). (1) Nobody shall be allowed to graze healthy, large cattle and other herds at maturity age (except goats and sheep) in *Alalili* located near residential areas. (1) It is not allowed to burn *Alalili* without guided permission. (1) It is not allowed to establish residential houses within *Alalili*. (1) It is not allowed to fetch or harvest any plant resource from *Alalili* without prior permission. (1) It is not allowed to sell any portion of *Alalili* to the immigrants. (1) It is strictly prohibited to cultivate the portion of *Alalili* for crop production. (1) Whoever is caught in the *Alalili* before allowed grazing season, is penalized an oxen or TZS 50,000/= for every countable misconduct. (1) The irresponsible livestock keepers are cursed by the *Laiboni* or suffer caning (stroked 70 times with a stick).
C6	Traditional rules and regulations	(1) All *Alalili* should be bounded or properly fenced (Live and local thorned fence). (1) All *Alalili* should be demarcated from residential areas (through a land use plan at the village level). (1) All *Alalili* should be managed by a special rangeland committee of a village (1) The committee and available institutions should conduct regular patrols to facilitate proper management implementation.

Data collection techniques

The partially reported traditional principles and guidelines for managing the utilization of *Alalili* systems were accessed through a systematic literature review (Athumani et al., 2023) whereby randomly selected literature sources gave the intended secondary data (Goldman, 2011; Mpondo et al., 2021; Nelson, 2012; Olekao, 2017; Sangeda & Maleko, 2018; Saruni, 2019; Selemani, 2020). The review was based on the relevance of information, whereby databases from Research for Life, EBSCOhost, and EMERALD through search engines of Google Scholar and Web of Science were accessed. Important keywords for searching the reference materials comprised of 'traditional rangeland management strategies of northern Tanzania', 'indigenous technologies in *Maasai* pastoralists', 'customary laws and by-laws', '*Alalili* systems', 'the *Maasai* people of Manyara and Arusha regions' as well as 'the indigenous knowledge in Ngorongoro'.

More data about the existence of the traditional principles and guidelines for managing the utilization compliance of the *Alalili* systems were collected through participatory field surveys. The survey was conducted in each village that comprised sampled *Alalili* systems in their respective districts. Documentation of the existing traditional principles and guidelines, surveyed types of *Alalili* systems, and land use categories within which they are located were obtained through key informant interviews and focused group discussions. Data regarding the compliance status of *Alalili* systems to the documented traditional principles and guidelines were collected through direct observation, household surveys, key informant interviews (KIIs), and focused group discussions (FGDs) with the adoption of questionnaires and checklists (Rono, 2018). Data regarding the compliance of *Alalili* systems to stocking rate, being unknown, was obtained through calculations that adopted an international standard of estimating animal unit equivalent (AUE) per hectare (ha) (FAO & Upton, 2011; Pratt & Rasmussen, 2001; Redfearn & Bidwell, 2017).

Data analysis

Narrative and descriptive analysis techniques through NVivo software (NVivo 12) were used to analyze the documented traditional principles and guidelines useful in managing the utilization compliance of *Alalili* systems (Murray, 2004; Thuv, 2023; Young et al., 2018). The qualitative data from the field survey were manually sorted, organized, coded, and converted into the quantitative format by using Microsoft Excel software for Windows 11 (Lihepanyama et al., 2024). Chi-square tests were used to analyze the compliance status of *Alalili* systems with the documented traditional management principles and guidelines, whereas an independent sample t-test was used to understand the variation in stocking rate between types of *Alalili* systems. Results regarding the compliance status of *Alalili* systems were presented in the form of tables, figures, and percentages. On the other hand, results regarding the recommended annual stocking rates for each type of *Alalili* system were presented in the form of Mean ± S.E., where S.E. stands for the standard error of the mean. Before analysis, the data were tested for both normality and homogeneity of variance through the Shapiro-Wilk test and Levene's test, respectively, and later analyzed through R version 4.2.3. A p-value of $p < 0.05$ was considered significant.

Research ethics

This research was approved by the Tanzanian Commission for Science and Technology (COSTECH), the Ministry of Natural Resources and Tourism through the Tanzania Wildlife Research Institute (TAWIRI), Tanzania Wildlife Management Authority (TAWA), and the Ngorongoro Conservation Area Authority (NCAA). Permission for research in communities was obtained from relevant local and district authorities.

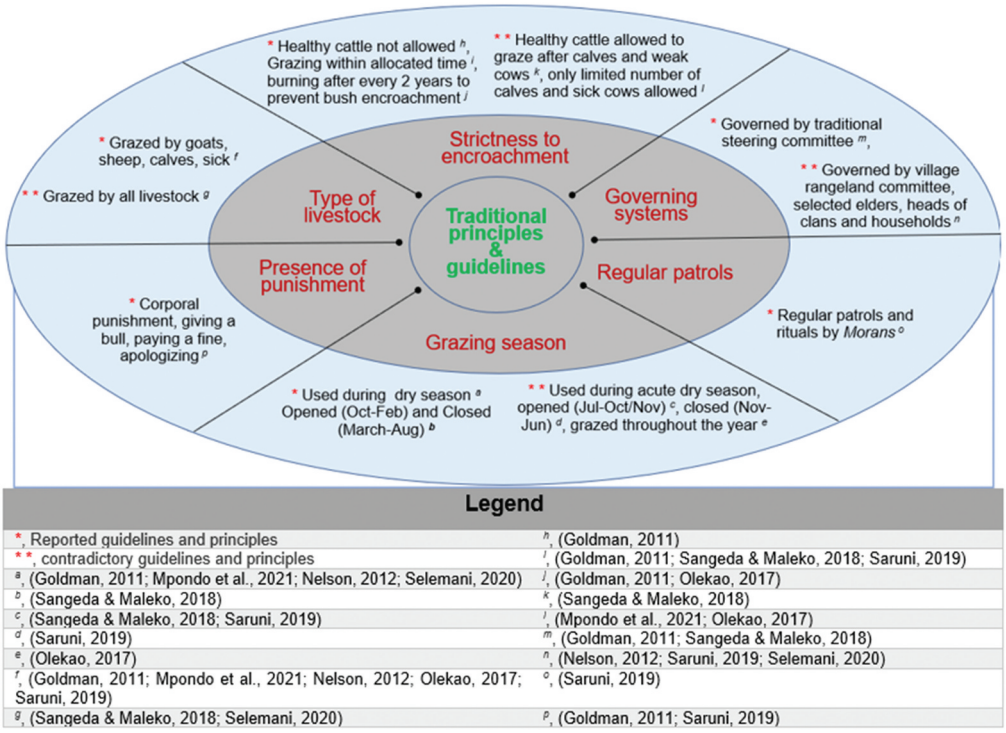
Results

Traditional alalili principles and guidelines from surveyed literature

Six aspects of the traditional principles and guidelines used for managing the utilization and sustainability of *Alalili* systems were recorded from the literature survey and summarized into a comparative outline (Figure 2). These were comprised of grazing season (time), type of livestock planned for grazing, strictness to the encroachment behaviors, presence of traditional governing systems, conduction of regular patrols, and presence of penalties. Some principles and guidelines from the same aspect depicted contradicting information recorded from different works of literature (Figure 2; see Table 3). The observed contradiction resulted in a comprehensive sorting and alignment of the traditional principles and guidelines as described in the subsequent section.

Comprehensive checklist of harmonized traditional principles and guidelines

Generally, the traditional principles and guidelines for managing *Alalili* systems documented during the field survey were grouped into four main aspects. These



Legend

*, Reported guidelines and principles	[h], (Goldman, 2011)
* *, contradictory guidelines and principles	[i], (Goldman, 2011; Sangeda & Maleko, 2018; Saruni, 2019)
[a], (Goldman, 2011; Mpondo et al., 2021; Nelson, 2012; Selemani, 2020)	[j], (Goldman, 2011; Olekao, 2017)
[b], (Sangeda & Maleko, 2018)	[k], (Sangeda & Maleko, 2018)
[c], (Sangeda & Maleko, 2018; Saruni, 2019)	[l], (Mpondo et al., 2021; Olekao, 2017)
[d], (Saruni, 2019)	[m], (Goldman, 2011; Sangeda & Maleko, 2018)
[e], (Olekao, 2017)	[n], (Nelson, 2012; Saruni, 2019; Selemani, 2020)
[f], (Goldman, 2011; Mpondo et al., 2021; Nelson, 2012; Olekao, 2017; Saruni, 2019)	[o], (Saruni, 2019)
[g], (Sangeda & Maleko, 2018; Selemani, 2020)	[p], (Goldman, 2011; Saruni, 2019)

Figure 2. Traditional principles and guidelines for managing the utilization of *Alalili* systems as reported from the surveyed literature.

Table 3. A list of traditional principles and guidelines for managing the utilization of *Alalili* systems as reported from the surveyed literature

Aspects reported	Reported principles and guidelines	Contrasting principles and guidelines
Grazing season (time)	(a) *Alalili* systems should be used during the dry season (Goldman, 2011; Mpondo et al., 2021; Nelson, 2012; Selemani, 2020). (b) *Alalili* systems should be closed during the wet season (usually March to August) and open during the late dry season (usually October to February) (Sangeda & Maleko, 2018).-	(a) *Alalili* systems should be utilized during the acute dry season only (Sangeda & Maleko, 2018; Saruni, 2019). (b) *Alalili* systems should be closed during the rainy season (usually November to June) and open during the dry season (usually July to October or November) (Saruni, 2019). (c) *Alalili* systems are grazed by the young livestock all year round (Olekao, 2017).
Type of livestock planned for grazing	*Alalili* systems should be grazed by goats, sheep, calves, and sick or deprived livestock only (Goldman, 2011; Mpondo et al., 2021; Nelson, 2012; Olekao, 2017; Saruni, 2019).	*Alalili* systems can be grazed by all kinds of livestock in consideration of different allocated durations (Sangeda & Maleko, 2018; Selemani, 2020).
Strictness to the encroachment behaviors	(a) Nobody is allowed to graze healthy cattle in the *Alalili* systems (Goldman, 2011). (b) Grazing should be conducted only during the right time allocated by the traditional assembly (Goldman, 2011; Sangeda & Maleko, 2018; Saruni, 2019). (c) Burning of pastures in the *Alalili* systems should be done every two years to prevent bush encroachment and allow the regrowth of good and healthy grasses (Goldman, 2011; Olekao, 2017).	(a) Healthy cattle can be grazed in the *Alalili* systems after some days of grazing calves and weak cows (Sangeda & Maleko, 2018). (b) Grazing of calves and sick cows can be conducted all year round restricted to only a few or a limited number of stockings (Mpondo et al., 2021; Olekao, 2017). –
The presence of traditional governing systems	Management and use of *Alalili* systems should be taken care of by the traditional steering committee led by *Maasai* elders (Goldman, 2011; Sangeda & Maleko, 2018).	Management and use of *Alalili* systems should be taken care of by the village rangeland management committee in collaboration with traditionally selected elders and heads of individual clans or households (*Bomas* in *Maasai* language) (Nelson, 2012; Saruni, 2019; Selemani, 2020).
Conduction of regular patrols	*Alalili* systems should be safeguarded against invaders through regular patrols and rituals by *Morans* (*Maasai* warriors forming traditional rangeland scouts) (Saruni, 2019).	–
Presence of punishments	Any person who deviates from the rules of grazing in the *Alalili* systems shall be punished including corporal punishment, giving a bull, heavy fining, and apologizing to the traditional assembly and community (Goldman, 2011; Saruni, 2019).	–

Table 4. A list of existing traditional strategies for managing the utilization, suitability, and sustainability of *Alalili* systems (Source: Field survey 2022)

Categories of the Alalili Management Strategies	Aspects recorded	Existing principles and guidelines
Principles and guidelines that protect *Alalili* systems from degradation principles	Grazing season (time)	(1) Grazing activities in the *Alalili* systems should be undertaken during the dry season only. (2) *Alalili* systems should be closed during the wet season (usually December to June) and open during the dry season (usually July to November). However, the wet and dry seasons shall be determined by the selected committee in the village considering the climatic condition of the respective year. (3) *Alalili* systems should not be grazed by livestock all year round to avoid scarcity of pastures during the acute dry seasons.
	Type of livestock planned for grazing and location of *Alalili* systems	(1) *Alalili* systems located near households (*Bomas*) or residential areas should be grazed by goats, sheep, calves, weak or sick, and lactating stocks. (2) *Alalili* systems located far away from the residential areas should be grazed by healthy cattle and small livestock capable of walking at a long distance. (3) Private and small-sized *Alalili* systems should be located near residential areas for easy serving of small, weak, sick, and lactating livestock. (4) Communal and large-sized *Alalili* systems should be located distantly from residential areas but near water sources to provide enough space for grazing and avoid overstocking in one area
	Strictness to the encroachment behaviors	(1) Healthy livestock are strictly not allowed to graze in the *Alalili* systems reserved for small, deprived, and lactating stocks. (2) Activities such as fire burning, building residential houses (huts), fetching plant resources, crop cultivation, and selling the portion of *Alalili* systems are strictly not allowed. (3) *Alalili* systems should be enclosed by a traditional live and thorned fence to demarcate them from other open grazing areas set aside for both wet and dry seasons.
	Estimated stocking rate	Based on international standards, it is not allowed to undertake grazing of livestock in the *Alalili* systems beyond the prescribed stocking rate (animal unit equivalent) per annum to avoid degradation through overstocking and overgrazing.
Management and implementation practices that protect *Alalili* systems from vanishing	The formulation of traditional governing systems	(1) The overall management and use of communal *Alalili* systems should be done by a locally devised steering committee comprised of members selected from each of the existing rangeland management institutions (village rangeland committee, *Laigwanani*/*llaigwanaki*, *Morani*, and *Laiboni*). (2) The management and use of private *Alalili* systems should be undertaken by traditionally selected elders and heads of individual clans or households (*Bomas*) owning the respective *Alalili* systems. (3) Grazing activities in the *Alalili* systems shall be conducted following the decision meeting of the steering committee and not otherwise.
	Conducting regular patrols	Regular patrols and rituals should be conducted regularly (on a daily basis) by range scouts (a group of few members selected from *Morans*) to ensure the safety, suitability, quality, and quantity of pastures in the *Alalili* systems.
	Giving punishments	Any person or household who deviates from the rules of grazing in the *Alalili* systems shall be severely punished through:- (a) Penalties such as giving a bull or paying a huge amount of money prescribed by the committee. (b) Corporal punishment (most applied to young) (c) Curses and (d) Apologies to the traditional assembly and the general community.

comprised aspects for governing the grazing seasons, types of livestock, and the location of *Alalili* systems, restrictions on encroachment behaviors, and stocking rate (see Table 4). They were termed principles that protect *Alalili* systems from degradation.

Principles and guidelines that protect Alalili from degradation practices

The pastoralists are not allowed to take their livestock into *Alalili* systems before the definite time, i.e. during the dry season. According to this principle (Figure 3a), the grazing activities in *Alalili* systems will be deemed illegal only if they are undertaken in a duration other than the dry season. Calves, goats, sheep, weak or sick, and lactating stocks are the intended groups that are to be grazed in the *Alalili* systems located near residential areas, meanwhile, large healthy cattle and other herds at maturity age should graze in *Alalili* systems that are far from residential areas (Figure 3b). Thus, taking livestock other than the recommended group of stocks into any of the irrespective *Alalili* systems is

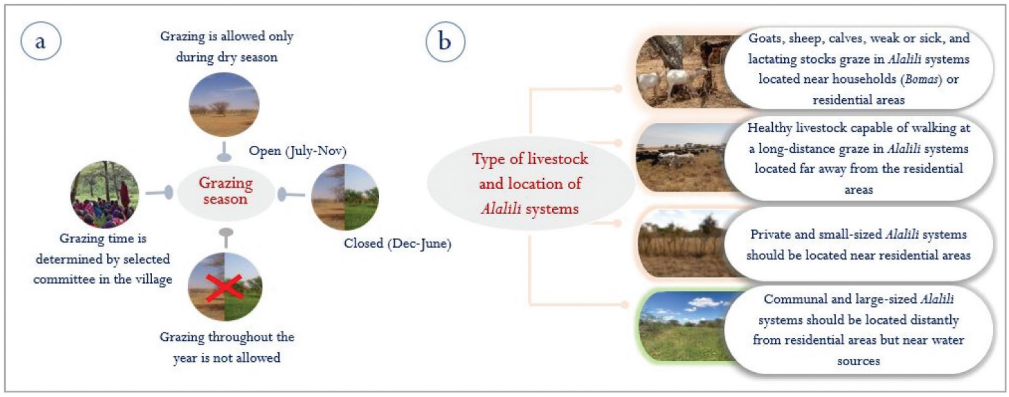


Figure 3. Traditional principles and guidelines for governing (a) grazing seasons and (b) types of livestock and the location of *Alalili* systems (Source: Ffield survey 2022).

regarded as an illegitimate act. It is strictly prohibited to do any activity that would lead to encroachment effects within *Alalili* systems (Figure 4a). Therefore, activities such as fire burning, building residential houses (huts), fetching plant resources, cultivating the portion of *Alalili* for crop production, and selling the portion of *Alalili* to immigrants are all considered disciplinary misconduct. *Alalili* systems should be bounded or properly fenced (Live and/or locally thorned fence) to have permanent boundaries and reduce encroachment habits. On the other hand, the *Maasai* community has had an undetermined stocking rate for their *Alalili*, although an overall average annual stocking rate with a reference made to international standards is 0.988 animal unit equivalent (AUE) per hectare (ha) (FAO & Upton, 2011; Pratt & Rasmussen, 2001; Redfearn & Bidwell, 2017). Livestock grazing beyond a recommended annual stocking rate per hectare shall be considered an unlawful habit that will lead to rangeland degradation (Figure 4b).

Compliance with principles and guidelines against Alalili systems degradation

Compliance with planned grazing time

Generally, 46% of the surveyed *Alalili* systems complied with principles regarding grazing season, i.e. livestock were allowed to graze during the dry season only, while 54% of *Alalili* systems did not comply with the principles (Figure 5). However, there was no significant variation between the proportion of complied and non-compliant *Alalili* systems ($\chi^2 = 0.681$, df = 1, $p = 0.409$). On the other hand, the proportion of *Alalili* systems that failed to comply with grazing season principles was relatively higher than the ones that complied in both communal and private categories. Similarly, non-compliant *Alalili* systems depicted a relatively higher proportion than the complied *Alalili* systems within each land use category (Figure 5). Although the level of compliance didn't vary significantly within each type of *Alalili* ($\chi^2 = 0.306$, df = 1, $p = 0.580$), it varied significantly across land use categories ($\chi^2 = 11.48$, df = 3, $p = 0.009$).

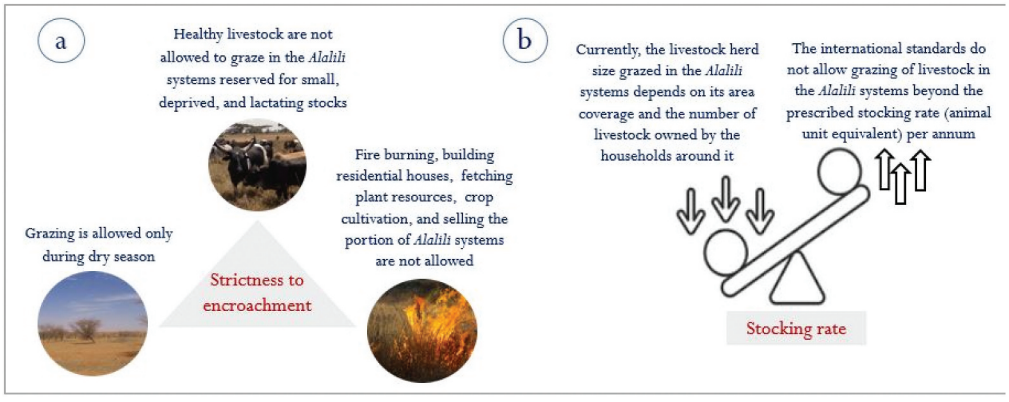


Figure 4. Principles and guidelines for governing (a) encroachment restrictions and (b) stocking rate (Source: Field survey 2022).

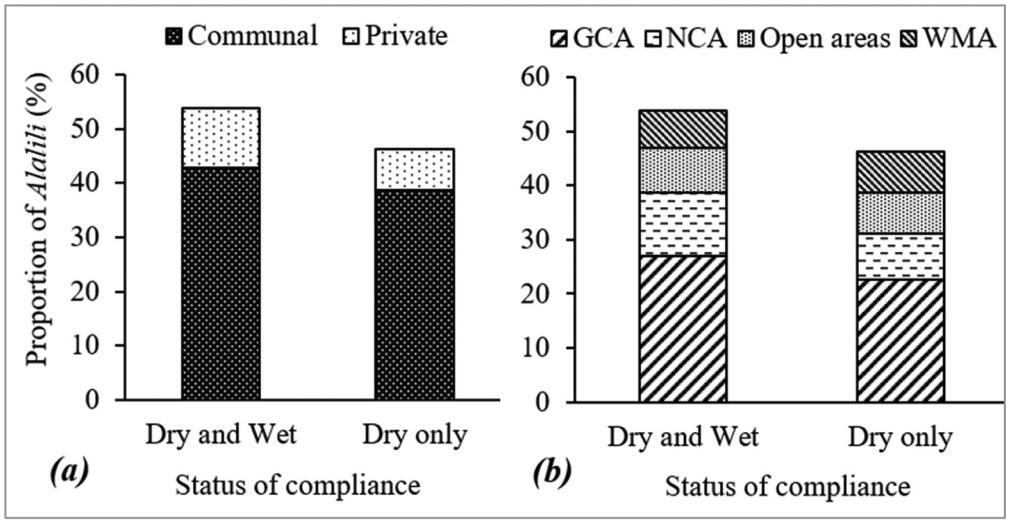


Figure 5. Proportion of *Alalili* systems complying with the grazing season across (a) Types of *Alalili* systems and (b) Land use categories.

Compliance with recommended types of livestock

The overall proportion of *Alalili* systems that complied with the recommended types of livestock to be grazed was 42% compared to 58% of the *Alalili* systems that did not comply with the suggested types of livestock to be grazed (Figure 6). However, there was no significant variation between the proportion of complied and non-compliant *Alalili* systems ($\chi^2 = 3.03$, df = 1, $p = 0.082$). Moreover, both communal and private *Alalili* systems depicted the highest proportion of non-compliance with the types of livestock compared to the ones that complied (Figure 6). Similarly, the proportion of non-compliance to the types of livestock was higher than the proportion depicted by complied *Alalili* systems within each land use category. Statistically, the level of compliance didn't vary significantly within each type of *Alalili* ($\chi^2 = 1.15$, df = 1, $p = 0.283$) as well as across land use categories ($\chi^2 = 5.82$, df = 3, $p = 0.121$).

Compliance with the predetermined encroachment restrictions

The overall proportion of *Alalili* systems that complied with principles emphasizing the restrictions to the encroachment of *Alalili* systems was 55%, being relatively higher than *Alalili* systems featuring non-compliance to encroachment restriction principles (45%) (Figure 7). However, the proportions between complied and non-complied *Alalili* systems didn't show any significant variation ($\chi^2 = 1.02$, df = 1, $p = 0.313$). On the other hand, communal *Alalili* systems depicted a relatively higher proportion of compliance than non-compliance in contrast to

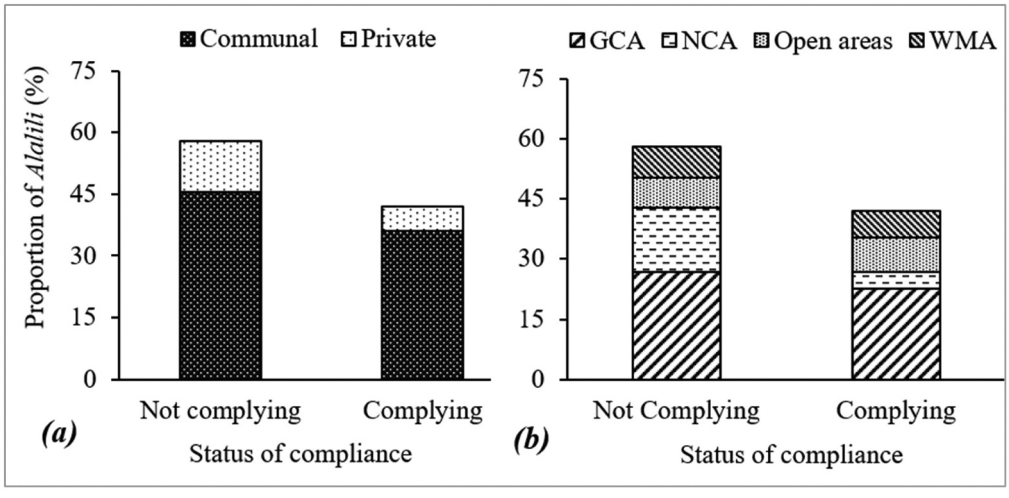


Figure 6. Proportion of *Alalili* systems complying with types of livestock across (a) Types of *Alalili* systems and (b) Land use categories.

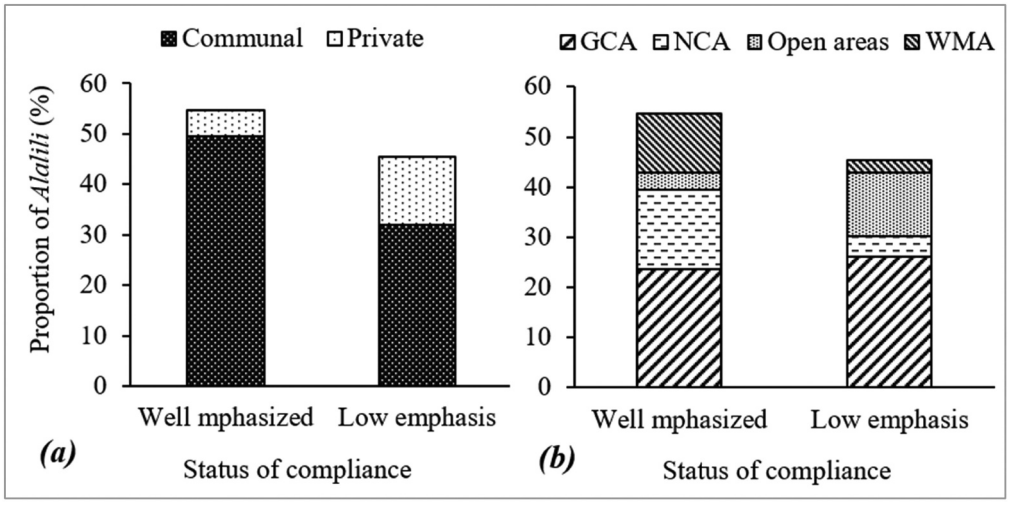


Figure 7. Compliance of *Alalili* systems with strictness to encroachment habits across *(a)* Types of *Alalili* systems and (b) Land use categories.

private *Alalili* systems that depicted a relatively higher proportion of non-compliance compared to the proportion of compliance (Figure 7). Statistically, there was a significant variation between the proportions of compliance and non-compliance with encroachment restriction principles within types of *Alalili* ($\chi^2 = 8.145$, df = 1, $p = 0.004$). Furthermore, *Alalili* systems within GCA, NCA, and WMA depicted relatively high proportions of compliance compared to that of non-compliance, in contrast to *Alalili* systems in the open areas that had a relatively lower proportion of compliance than non-compliance (Figure 7). The two proportions showed a significant variation across land use categories ($\chi^2 = 21$, df = 3, $p < 0.001$).

Compliance with fencing principles

Generally, *Alalili* systems that complied with fencing principles portrayed the lowest proportion (28%) compared to 72% of the surveyed *Alalili* systems that were not fenced (Figure 8). The two proportions (i.e. compliance and non-compliance) depicted a significant variation ($\chi^2 = 33.1$, df = 1, $p < 0.001$). On the other hand, communal *Alalili* systems depicted the highest proportion of non-compliance than that of compliance, in contrast to private *Alalili* systems featuring a relatively higher proportion of compliance than non-compliance with fencing principles (Figure 8). The level of compliance with fencing varied significantly within each type of *Alalili* ($\chi^2 = 33.05$, df = 1, $p < 0.001$). Although the variation between levels of compliance across land uses

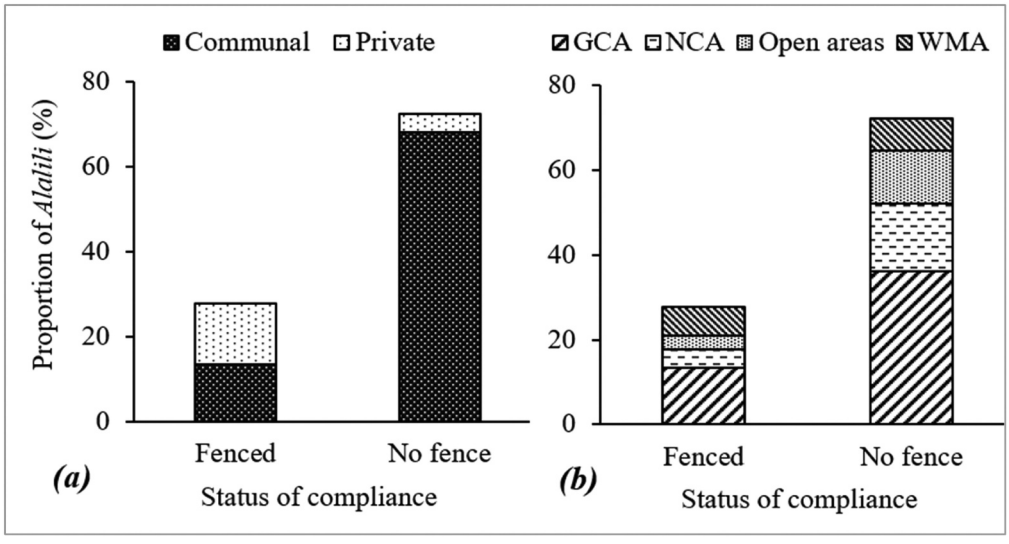


Figure 8. Proportion of *Alalili* systems complying with fencing principles across (a) Types of *Alalili* systems and (b) Land use categories.

was not significant ($\chi^2 = 4.172$, df = 3, $p = 0.243$), non-complied *Alalili* systems depicted a relatively higher proportion than the complied ones in each land use category (Figure 8).

Compliance with the recommended stocking rate

The recommended estimates of annual stocking rates for both communal and private *Alalili* systems were 887 ± 124 AUE and 237 ± 41.1 AUE, respectively, depicting a significant variation between them ($t = 4.99$, df = 112, $p < 0.001$). In general, *Alalili* systems featuring non-compliance to the recommended stocking rate (above AUE) depicted the highest proportion (52%) compared to 48% of *Alalili* systems that complied with the stocking rate (within AUE) (Figure 9). Nevertheless, no significant variation was observed between the proportions of compliant and non-compliant *Alalili* systems ($\chi^2 = 0.21$, df = 1, $p = 0.647$). On the other hand, communal *Alalili* systems depicted a relatively higher proportion of compliance with stocking rate than the proportion of non-compliance, in contrast to private *Alalili* systems, which had a relatively lower proportion of compliance with stocking rate than that of non-compliance (Figure 9). There was no significant variation between proportions of compliance and non-compliance within types of *Alalili* ($\chi^2 = 2.797$, df = 1, $p = 0.094$). Conversely, the proportions between compliance and non-compliance depicted a significant variation across land use categories ($\chi^2 = 11.48$, df = 3, $p = 0.009$). The complied *Alalili* systems in GCA depicted a relatively higher proportion compared to non-complied ones, which were relatively less. In contrast to GCA, *Alalili* systems in open areas and WMA had a relatively lower proportion of compliance than non-compliance, whereas NCA depicted an equal proportion of compliance levels (Figure 9).

Community perception on the utilization compliance of Alalili systems

On average, 70% of respondents agreed that compliance attributes are effectively applied for managing the utilization of *Alalili* systems, while only 30% disagreed about the effective application of the compliance attributes (Figure 10). The proportion of male respondents who agreed with the effective application of compliance attributes was 68%, while those who disagreed were 32% (Figure 10). On the other hand, female respondents who agreed with the effective application of the compliance attributes were 78%, while those who disagreed were 22% (Figure 10). Moreover, there was a relatively higher proportion of respondents who positively agreed that compliance attributes are effectively applied within land uses compared to respondents who disagreed. In contrast to other attributes, C1 behaved differently, whereby the proportion of respondents who positively agreed with its effective application was relatively lower than the proportion of respondents who disagreed (Figure 11).

Management practices for the sustainability of alalili systems

Three aspects of the traditional and local-based management practices were documented during the field survey,

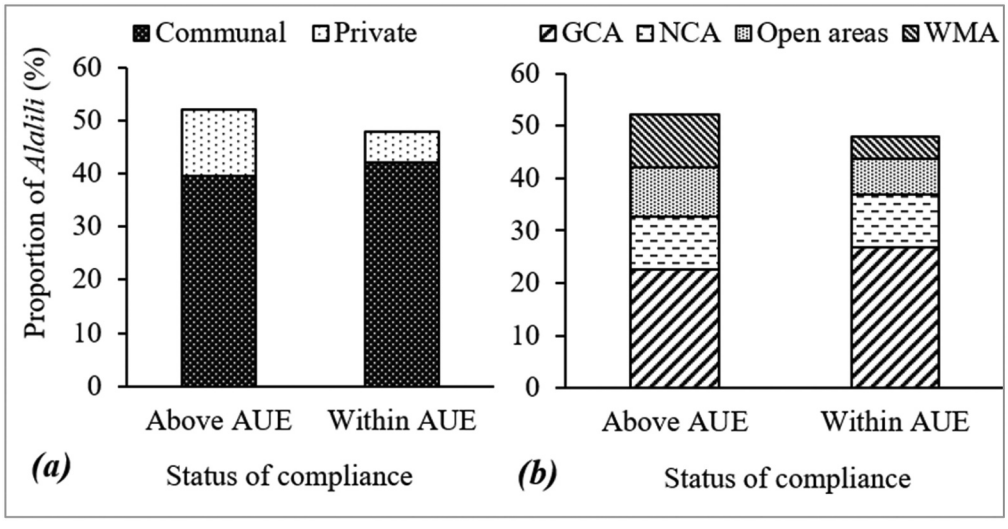


Figure 9. Proportion of *Alalili* systems complying with stocking rate across (a) Types of *Alalili* systems and (b) Land use categories.

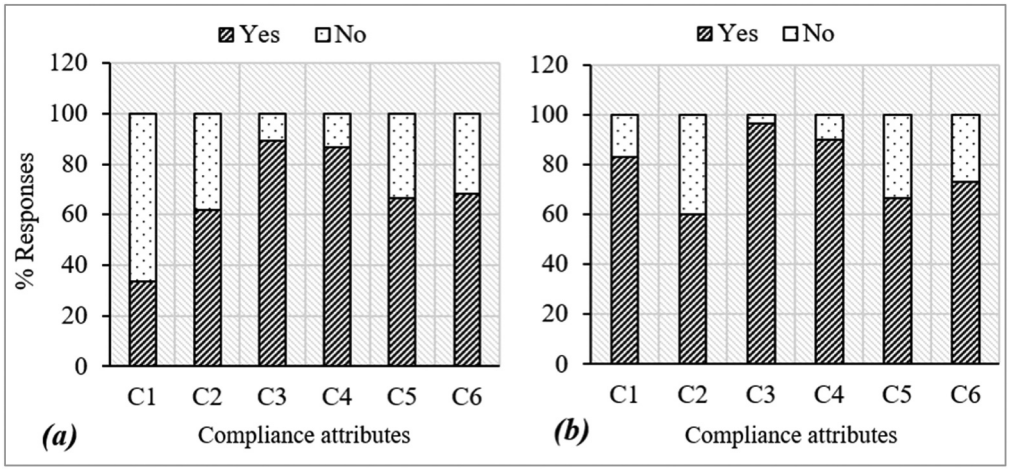


Figure 10. The proportion of complying attributes to the management of *Alalili*: (a) Male respondents (b) Female respondents. Abbreviations: *C1 = Grazing seasons identification; C2 = Modality of conducting grazing activities; C3 = Availability of the Managing Institutions; C4 = Existence of Institutional arrangements; C5 = Abiding with formalized Laws and By-laws; C6 = Observing the existing Traditional rules and regulations*

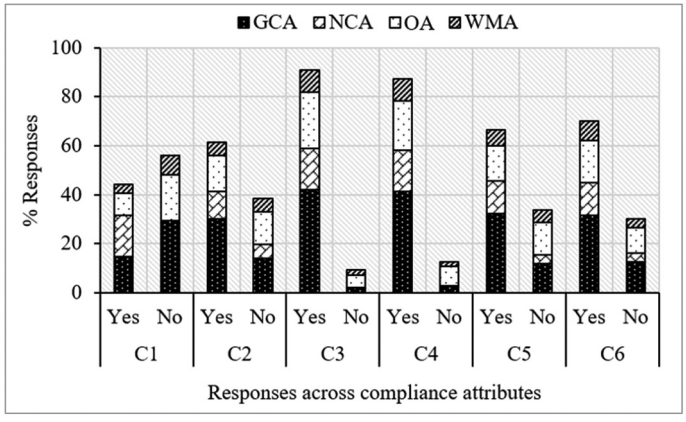


Figure 11. The proportion of complying attributes across land uses. Abreviations: OA = Open areas; *C1 = Grazing seasons identification; C2 = Modality of conducting grazing activities; C3 = Availability of the Managing Institutions; C4 = Existence of Institutional arrangements; C5 = Abiding with formalized Laws and By-laws; C6 = Observing the existing Traditional rules and regulations*

i.e. the governing systems, punishments, and local patrols and rituals (Figure 12; see Table 4). They are considered as the regulatory tools from which *Alalili* systems are protected from total loss through the implementation of the traditional principles and guidelines for compliance as cumulatively depicted by the rapporteurs during the KII and FGD sessions;

KII-NGORONGORO-2

The Maasai pastoral community devoted powers for managing Alalili systems to traditional governing systems including their locally devised management institutions, i.e. village rangeland committee, Laigwanani/Ilaigwanaki, Morani, and Laiboni (Table 5) (KII/Alalili field survey/Ngorongoro District/November 2022).

FGD-KITETO-5

The management institutions are responsible for planning the grazing seasons and setting a specific standard and status that will determine the time to open Alalili for livestock to graze. They are also responsible for formulating laws, by-laws, rules, and management regulations at the village level, setting the penalties/punishment for anybody who commits misconduct, as well as establishing boundaries for Alalili and open pasture lands. They are planners of age-set roles (Table 6) that partly help to facilitate the management and protection of Alalili systems from disappearance, being supported by institutional arrangements (FGD/Alalili field survey/Kiteto District/October 2022).

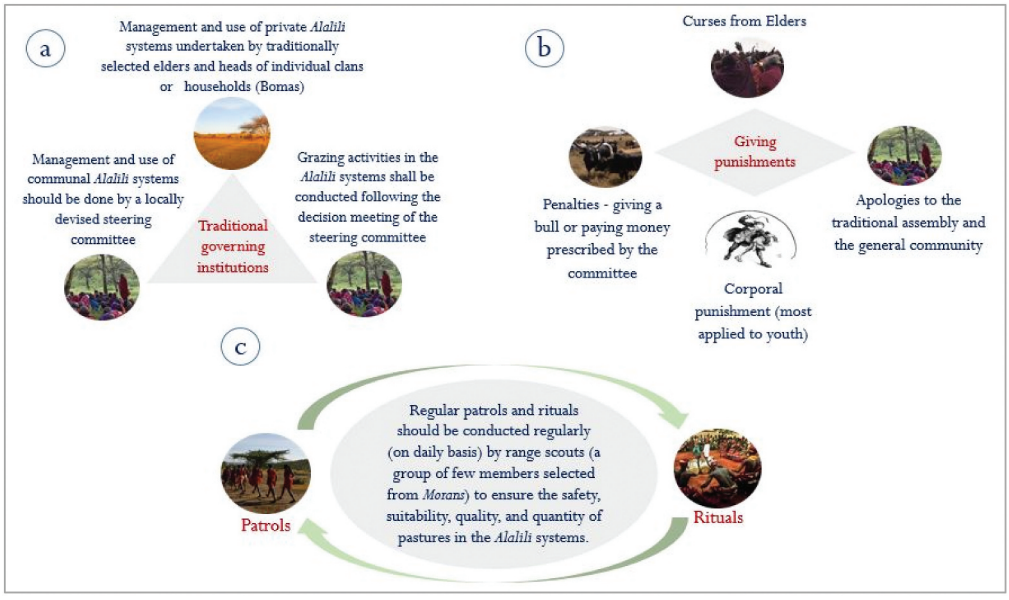


Figure 12. *Alalili* management practices: (a) The governing institutions, (b) Giving punishment, and (c) Regular patrols and rituals (Source: Field survey 2022).

Table 5. *Maasai* devised institutions for *Alalili* management (Source: Field survey, 2022)

Management Institutions	
Village Rangeland Committee	It is a committee that is in charge of all rangelands within the village boundaries. It is comprised of members from the village government, *Laigwanani*, *Morani* (*Landiis*, *Korianga*, and *Nyangulo*), and *Laiboni*.
Laigwanani	A committee of elders/traditional leaders in a village who prepare laws and by-laws, as well as age-set roles
Morani	A group of *Maasai* warriors (*Landiis*, *Korianga*, and *Nyangulo*) in a village whose role is to implement the supervision and protection of *Alalili* systems. *Nyangulo* is a group of *Maasai* youths, *Morani* (expected successors of *Landiis* and *Korianga*), who take livestock to the planned grazing areas.
Laiboni	A group of traditional healers who set the curse principles for regulating the utilization of *Alalili*.

Table 6. Summary of age-set roles for *Alalili* management (Source: Field survey, 2022)

Age group	Age-set Roles
(i) *Laigwanani* (≥50 years)	(1) Are responsible for setting management guidelines & utilization standards of *Alalili* through meetings at the village level. (2) Making regulations, laws, and by-laws for managing *Alalili* systems. (3) Preparing the punishment and penalties for anybody who goes against the rules and principles. (4) Empowering the lower management groups i.e. *Morani* and *Nyangulo* to take care of *Alalili*.
(ii) *Morani Landiis* (35–49 years) and *Korianga* (25–34 years)	(1) To receive orders from *Laigwanani* to protect *Alalili* by fighting against invaders. (2) To guide the *Nyangulo* to implement the grazing timetable given by their elders. (3) To punish the pastoralists who go against regulations and rules. (4) To enclose or fence the *Alalili* plots. (5) To conduct regular patrols to assess the pasture status before deciding on the dates to start grazing.
Nyangulo (14–24 years)	(1) To take livestock in the *Alalili* for grazing following the guidance of the elder *Morani*. (2) To ensure that livestock are grazed to satisfaction. (3) To take livestock into water sources.
(iii) *Laiyoni* (0–13 years)	(1) They collaborate with women in taking care of calves, weak and lactating stocks as well as goats and sheep. (2) They are responsible for taking care of livestock at the short-term camps known as *Ronjo* under the supervision of *Nyangulo*. (3) They are also responsible for sweeping livestock into water sources for drinking.

KII-LONGIDO-1

Regular patrols are set to enhance the effective protection of both communal and private Alalili systems from all misconduct behaviors as well as facilitate proper management implementation through the conduction of rituals in the Alalili systems (Figure 12c) (KII/Alalili field survey/Longido District/May 2022).

FGD-SIMANJIRO-5

Punishments are set forth towards Alalili management whereby anybody who falls irresponsible will either be penalized (a bull or pay 50,000/- Tanzanian Shillings per misconduct) or suffer caning (70 strikes) and curses by Laiboni (Figure 12b) (FGD/Alalili field survey/Simanjiro District/October 2022).

Discussion

Categorization of traditional management principles and guidelines

The result section has depicted a variation between the traditional principles and guidelines reported from the surveyed literature and those that were recorded from the field survey. Some aspects that were previously reported as principles and guidelines by the literature, specifically the governing systems, punishments, and local patrols, are considered implementation management practices (Figure 12; see Table 4). This observation is supported by Mapinduzi et al. (2003) and Olekao (2017), who reported that traditional governing institutions are responsible for implementing the devised principles and guidelines for land and natural resources management across the *Maasai* land. These management practices are useful in protecting the *Alalili* systems from vanishing through harnessing and implementing the applicability of the reported principles and guidelines. They possess specific implications for the use and assure fundamental sustainability of the *Alalili* systems like other terrestrial ecosystems (Dale et al., 2000; Fischer et al., 2006).

Furthermore, the results section depicts four major aspects of indigenous principles that have been used in monitoring the sustainability and quality of rangelands through utilization compliance of *Alalili* systems, i.e. enhancing protection from degradation and prevention of local extinction. It was similarly reported that traditional principles of managing *Alalili* systems are an intervention that can be freely practiced without assisted restoration while preserving the potential ethics of community-driven conservation (Goldman, 2011; TPW, 2019). However, the existence of these principles and guidelines was not safe, being put in general terms with no distinguishing roles specifically sorted out for *Alalili* systems (Homewood et al., 2009; Selemani, 2020). Lack of recognition and proper documentation would lead to a gradual decline of these principles which are often associated with social-cultural changes and a lack of supporting policies (Nyariki et al., 2005). Thus, this categorization ensures their effective protection against loss while increasing an intention for formalization (Raycraft, 2021; URT, 2014). Monitoring the utilization compliance of *Alalili* systems through indigenous local-based principles and guidelines has been useful not only in sustaining the suitability of pastures but also in supporting the survival of desirable fodder species during extreme climatic conditions (Kilongozi et al., 2005; Olekao, 2017).

Implications of Alalili compliance with traditional management principles and guidelines

We observed that more than 50% of the surveyed *Alalili* systems across the rangelands of northern Tanzania are currently not complying with management principles that protect them from the effects of degradation and vanishing. This exposes *Alalili* to degradation pressures such as overgrazing, overstocking, deforestation for fuel wood, and encroachment, which in turn endanger the regeneration capacity, quality, and quantity of fodder plants for the next season (Holechek et al., 2017; Johnsen et al., 2019; UNEP, 2023). Failure to comply with the existing principles would promote a habit of grazing continuously throughout the year, which is not healthy for rangeland productivity and forage quality (Hezron et al., 2025; Sangeda & Maleko, 2018). On the other hand, not complying with traditional rules, laws, and by-laws, as well as denying the power within traditional management institutions and age-set roles, can accelerate conflicts over limited grazing resources (Saruni, 2018; Selemani, 2020). Studies have indicated that it would be productive if such *Alalili* management tools could be received and respected by government agencies and formal rangeland management authorities (Lind et al., 2020; Nelson, 2012; Olenasha et al., 2001). This will restrict the fragmentation of rangelands useful for both livestock and wildlife (NTRI, 2019) while settling the rising disputes over pastures (Wangchuk et al., 2023).

Although the incorporation of modern technology such as managing stocking density for *Alalili* systems has been unknown for centuries, this work has depicted that, many private *Alalili* systems are challenged with overstocking. In the northern Tanzania rangelands, fodder recovery in overstocked rangeland ecosystems tends to be difficult thus, increasing community vulnerability to the impacts of climate change and reducing livestock productivity (FAO & Upton, 2011; Mccabe, 2003; Pratt & Rasmussen, 2001; Redfearn & Bidwell, 2017; NTRI, 2019). Furthermore, as previously observed by Sangeda and Maleko (2018) and Homewood et al. (2009), the results depicted that the future of rangeland sustainability as a whole relies on the traditional management principles of *Alalili* systems through the governing capability of locally devised institutions. This work confirms that the traditional mechanism of ensuring the suitability and compliance state of *Alalili* systems for grazing activities is highly valued among the *Maasai* pastoral communities and has to be equally formalized into the existing management policies (Saruni, 2018; Selemani, 2020).

Conclusion

Challenges on multiple fronts, such as climate change, biodiversity loss, altered biogeochemical flows, social unrest, and injustices, are considered existential problems that face human societies. This research managed to document and harmonize the management principles and guidelines to better inform the policy and sustainable management practice of the *Alalili* systems, reversing the risks of their disappearance from the human-driven degradation pressures. This research further calls for the necessity of harnessing the traditional principles and guidelines as a crucial tool for the enhanced conservation, utilization compliance, and sustainability of the *Alalili* systems in conserving and restoring degraded rangelands. This study demonstrates how the traditional governing principles and guidelines have been playing an important role in the sustainable protection and consumption of indigenous and traditional rangeland conservation systems to mitigate the shortage of pastures. It adds to the evidence-based solutions proposed by UNEP for promoting the use of traditional and indigenous conservation strategies for crops and pastoralism (UNEP, 2023).

Despite the crucial historical importance displayed by the *Alalili* systems to the surrounding communities, this study depicts that there is still a risk of being overlooked by the local communities and a lack of knowledge about their roles in conserving biodiversity. For example, the findings in this study depicted that more than 50% of the surveyed *Alalili* systems did not comply with the traditional management principles and guidelines. Thus, failure to incorporate them into policy and contemporary conservation practices might amplify the proximity of *Alalili* systems and the general rangelands of northern Tanzania to degradation pressures and possible extinction threats.

Hence, characterizing the compliance of *Alalili* systems with the traditional management principles and guidelines marks the initial strategy of recognition and incorporation into policies and new conservation guidelines. These can be utilized by rangeland conservation stakeholders as tools to predict the possible effects of degradation and infringement pressures facing the rangelands of northern Tanzania. They account for different human-driven factors that deteriorate the sustainability and suitability of the rangelands in northern Tanzania regions while suggesting potential solutions. Failure to incorporate the applicability of these traditional and locally devised principles into the National Biodiversity Conservation Acts will further lead to their natural death and immemorable loss. Challenges like unsustainable land use practices, pressures of population growth, and socioeconomic and cultural dynamics can be easily solved if the traditional principles and guidelines are effectively put into action.

Therefore, it is recommended that the traditional principles be officially recognized by the policymakers and put into practice to add value to the traditionally conserved rangelands. The policy briefs concerning the protection of these locally devised management guidelines and principles will be a stepping stone toward the implementation of the 2030 UN agenda for sustainable development by promoting the utilization of indigenous and traditional knowledge (SDG 17) (UN, 2015).

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Data availability statement

Data have been submitted with this manuscript as supplemental materials

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